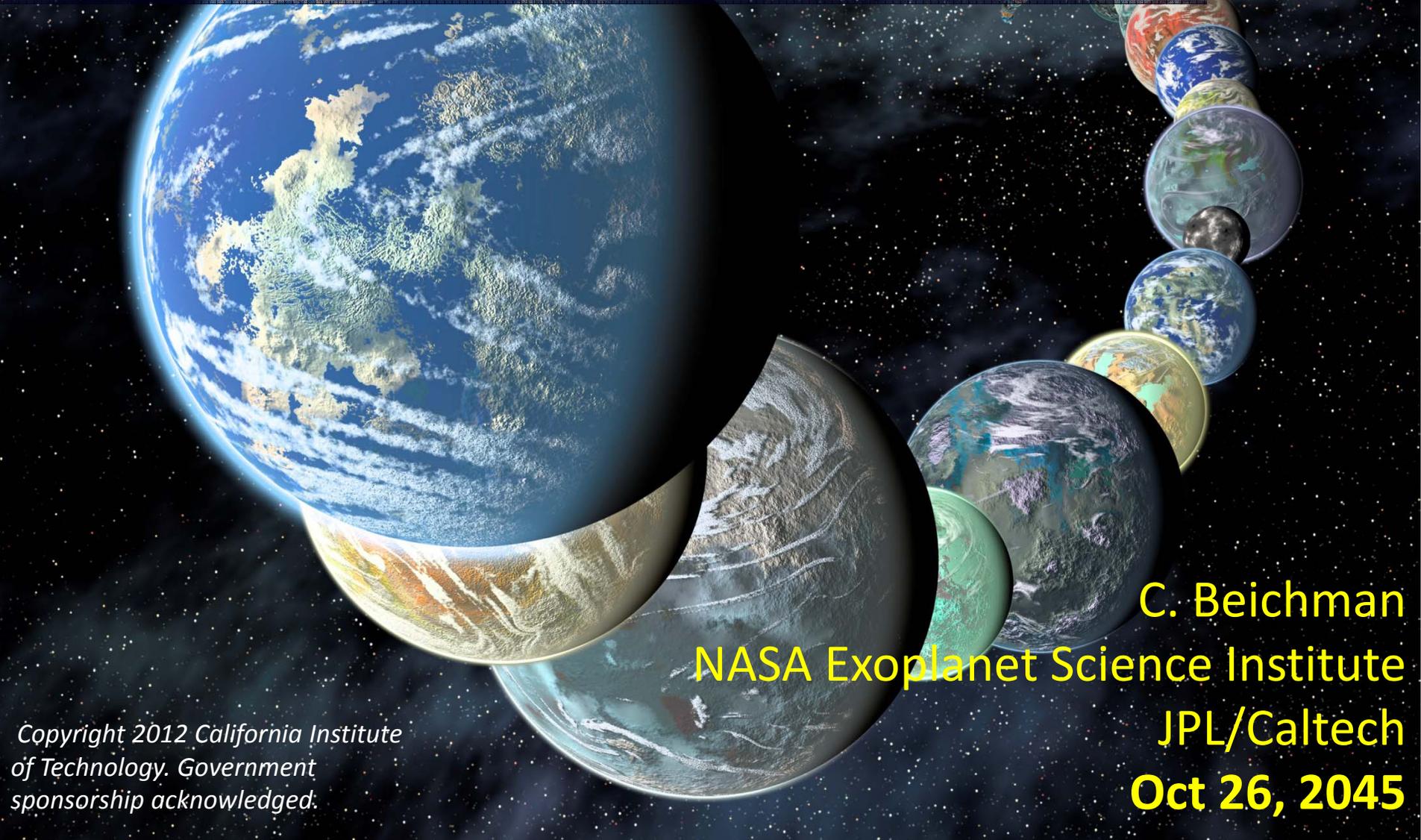


Welcome to the 50th Anniversary of Exoplanet Exploration



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C. Beichman
NASA Exoplanet Science Institute
JPL/Caltech
Oct 26, 2045

1940s-1980s: First Glimmers

Van de Kamp, Holmberg (1943)

- 10 M_{jup} astrometric planets come and go

Otto Struve (1952)

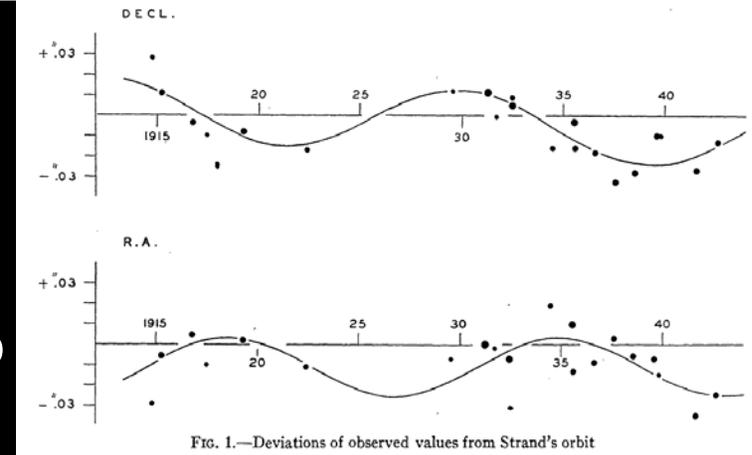
- “One of the burning questions of astronomy deals with the frequency of planet-like bodies in the galaxy which belong to stars other than the Sun...**How shall we proceed to find them?**”
- **Imaging** —“quite limited in scope”
- **Radial Velocity**--- “It is not unreasonable that a planet might exist a distance of 1/50 AU... causing the observed radial velocity of the star to oscillate with a range of 0.2 km/s---a quantity that might be just detectable.”
- **Transits**---“There would of course be eclipses...the loss of light in stellar magnitudes is about 0.02. This too should be ascertainable by modern photoelectric methods.”

Bruce Campbell and Gordon Walker (1988)

- “Seven stars show small, but statistically significant, long-term trends in the relative velocities...Companions of about 1-9 Jupiter masses are inferred.”

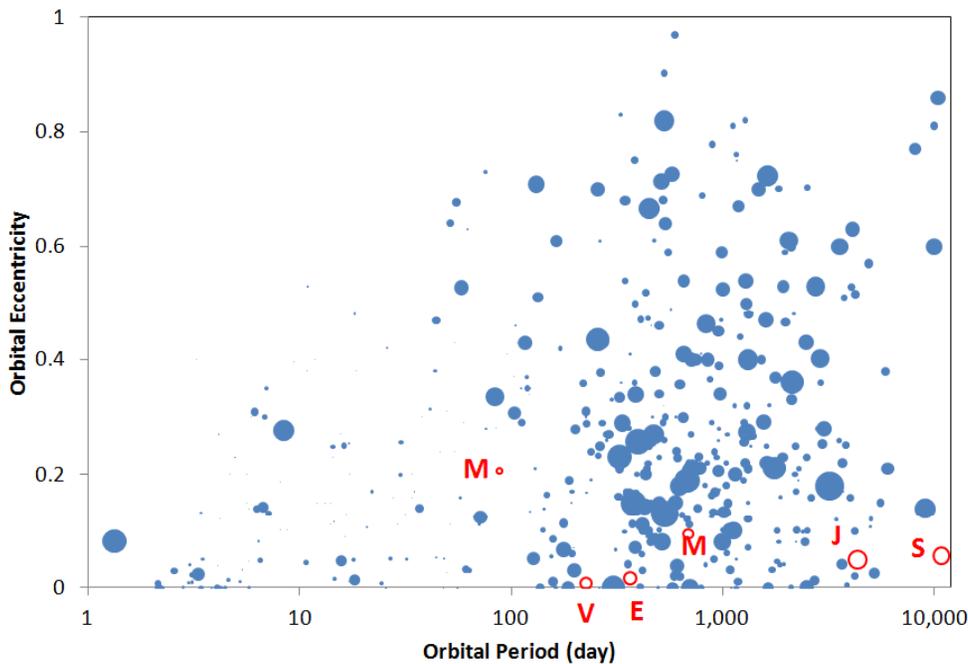
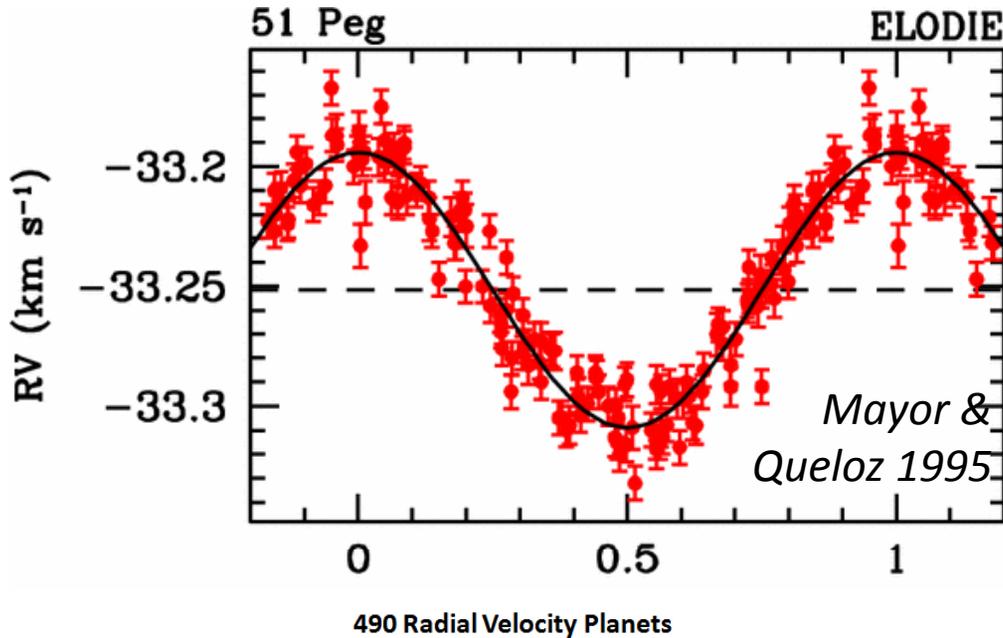
Latham et al 1989

- “*The unseen companion of HD114762 - A probable brown dwarf*”

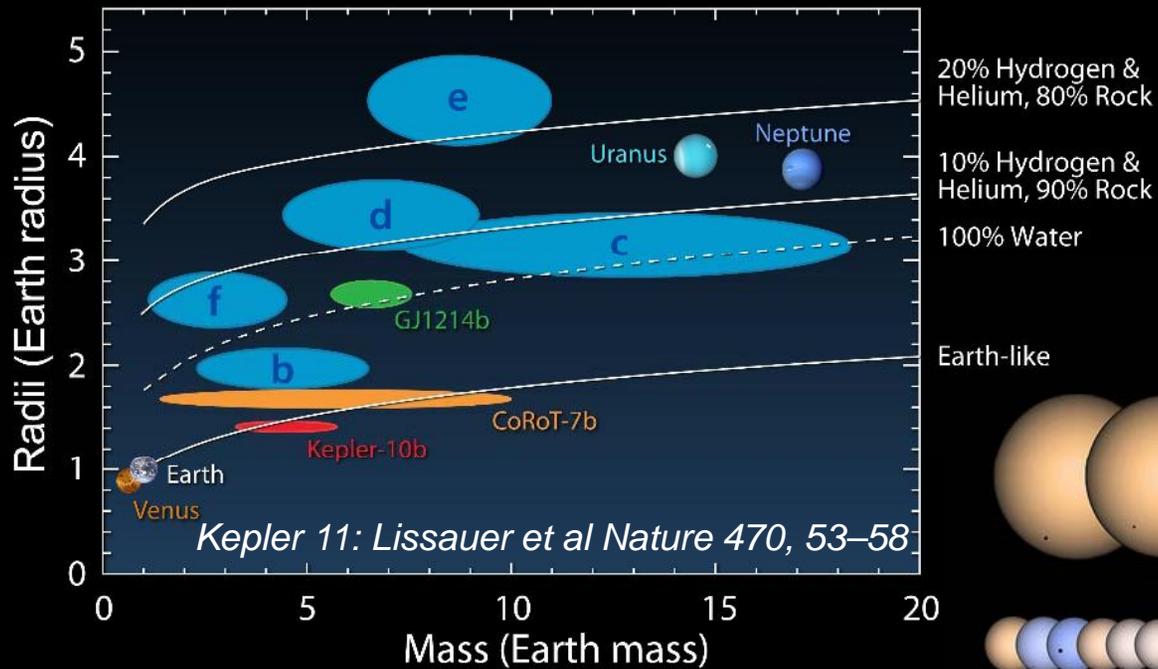


1995-2005: The Floodgates Open

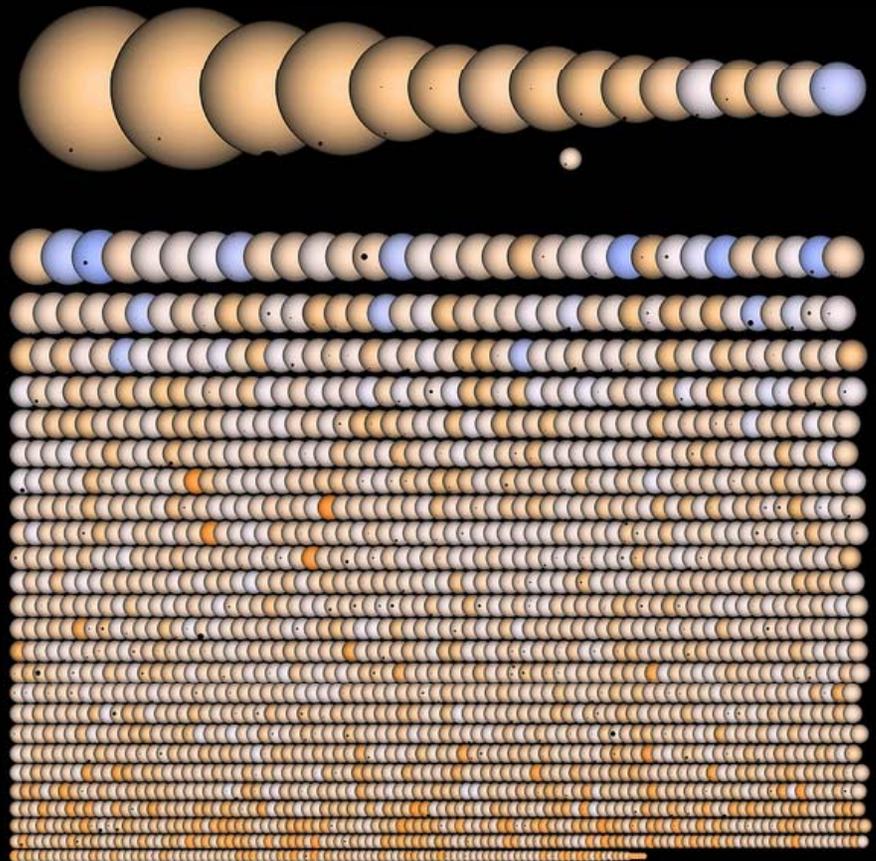
- **1995: “Annus Mirabilis:”** $0.5 M_{Jup}$ companion in a 4.2 day (!) orbit around 51 Peg
- Origins: “Advanced telescope searches for Earth-like planets and habitable environments around other stars.”
- 500 RV planets (NASA/Keck) reveal exoplanet architecture



2005-2015: The Decade of Transits



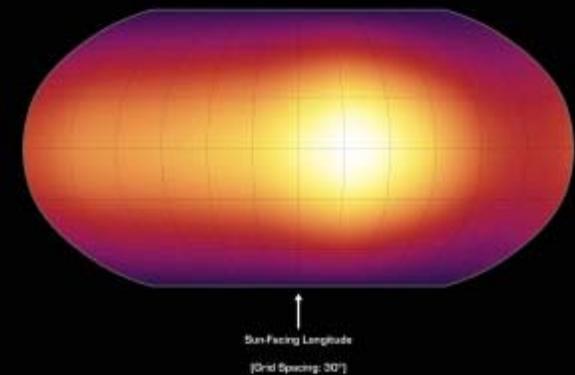
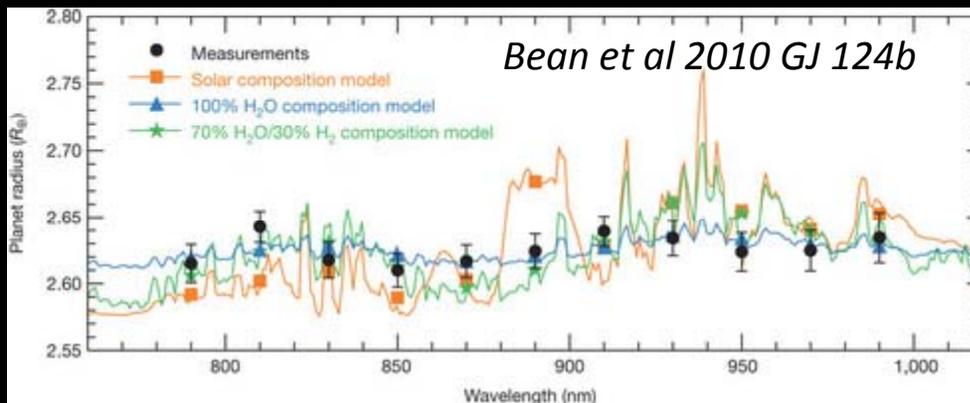
- First Ground based transits (2004)
- NASA's Kepler finds >2,000 candidates



2005-2015: Characterizing Giant Planets

On the subject of stars ... We shall never be able by any means to study their chemical composition. --- August Comte, 1835

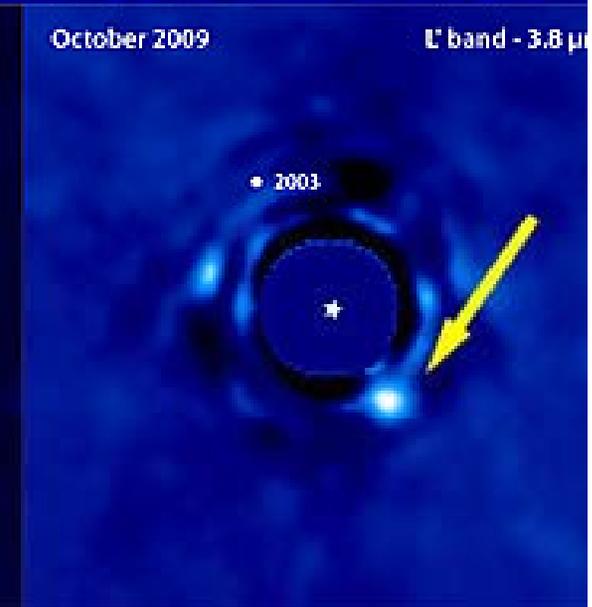
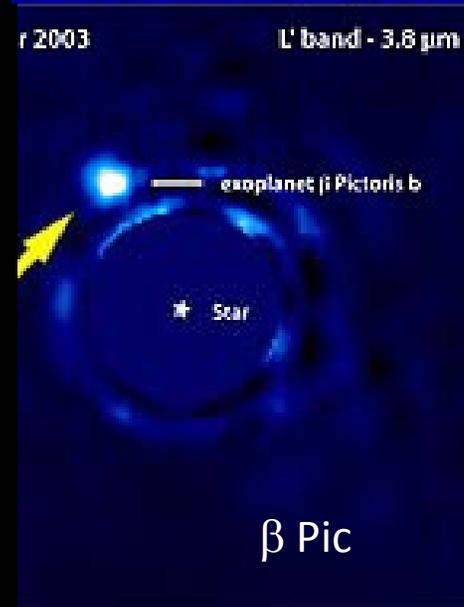
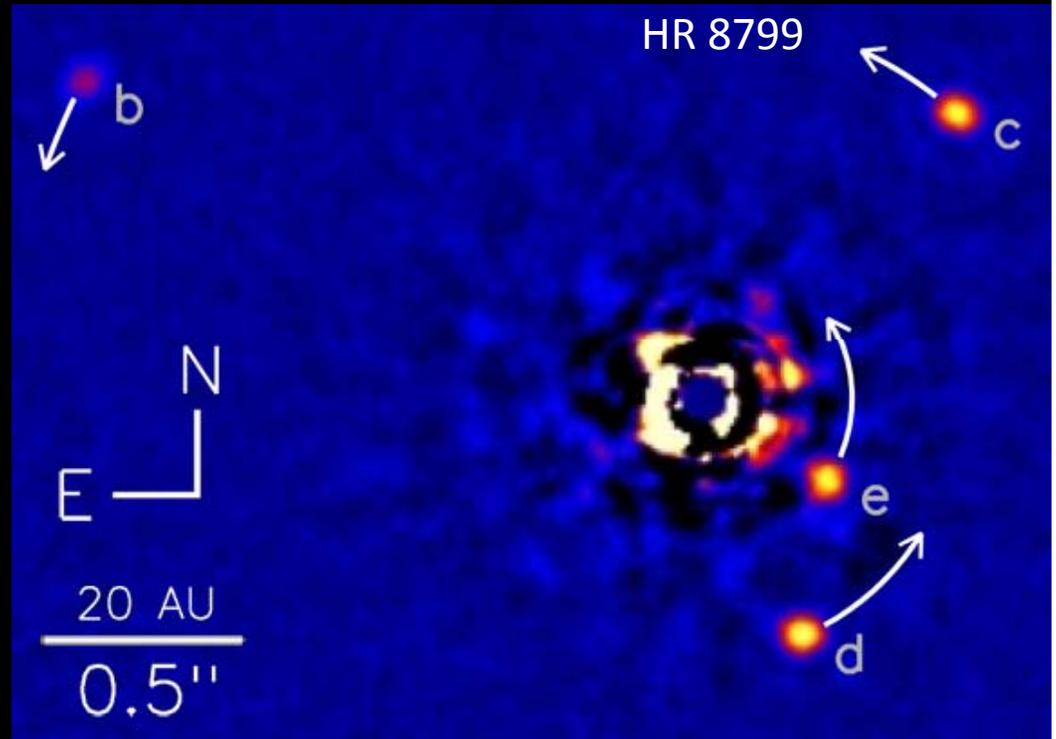
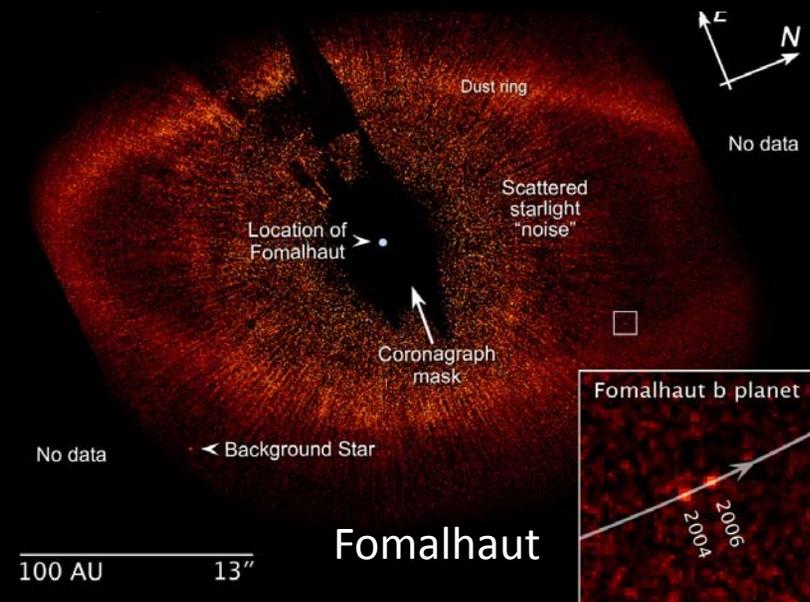
- Spitzer, HST, ground telescopes probe atmospheric composition (H_2O , CH_4 , CO_2), vertical structure & weather of planets



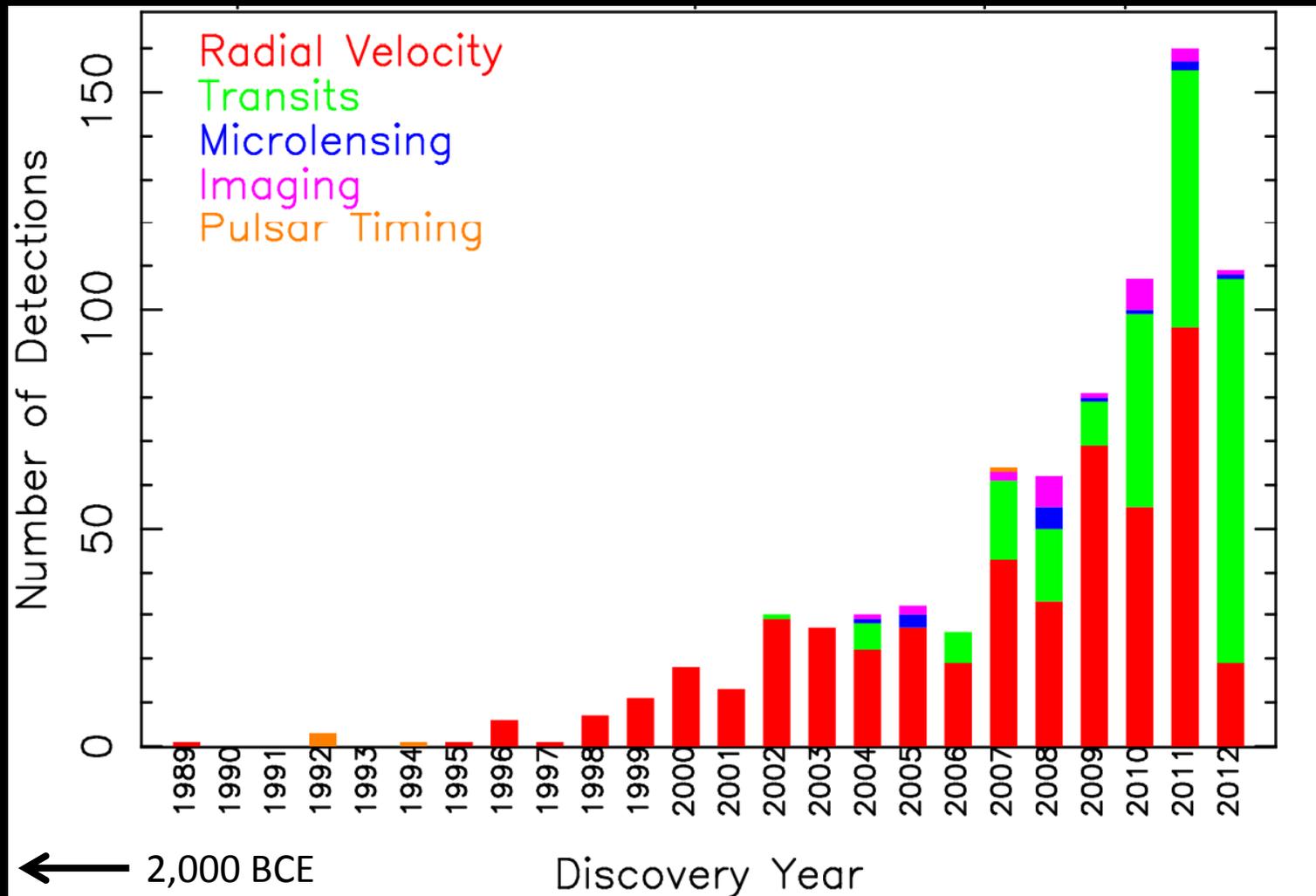
- NASA Planetary & Astrophysics jointly pick **both TESS and FINESSE Explorers** to find 1,000s of planets transiting bright stars (~30 of Habitable Zone Earths) and to make atlas of 100s of ice/gas giant spectra

2005-2015: Imaging Planets

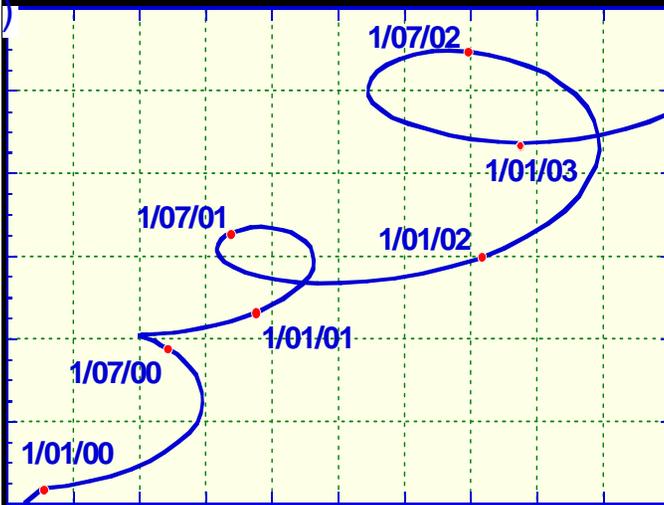
Young Jupiters on large orbits from space and ground with Extreme Adaptive Optics on 5-10 (30) m telescopes



33 Years Ago on Oct 26, 2012:
~~797~~ 798 Planets Around ~~629~~ 630 Stars
+ 2,320 Kepler Planetary Candidates

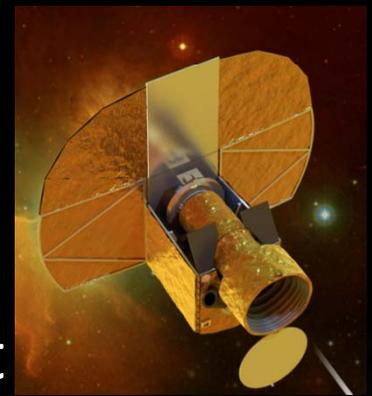


2015-2025: Census Taking, Images and Transits from Space

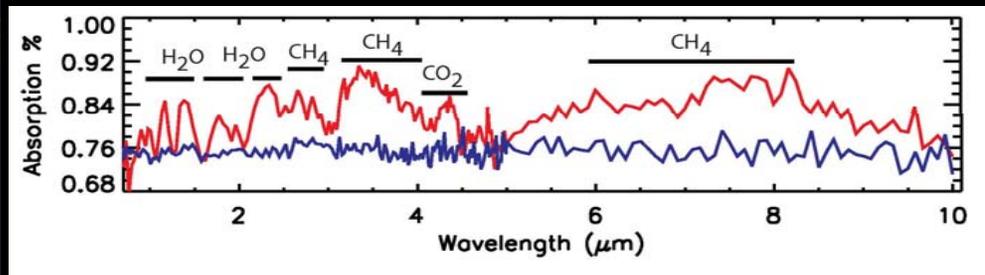


GAIA (ESA) finds >2,000 Jupiters @ <200 pc

CHEOPS (ESA) finds new transits & makes high precision light curves

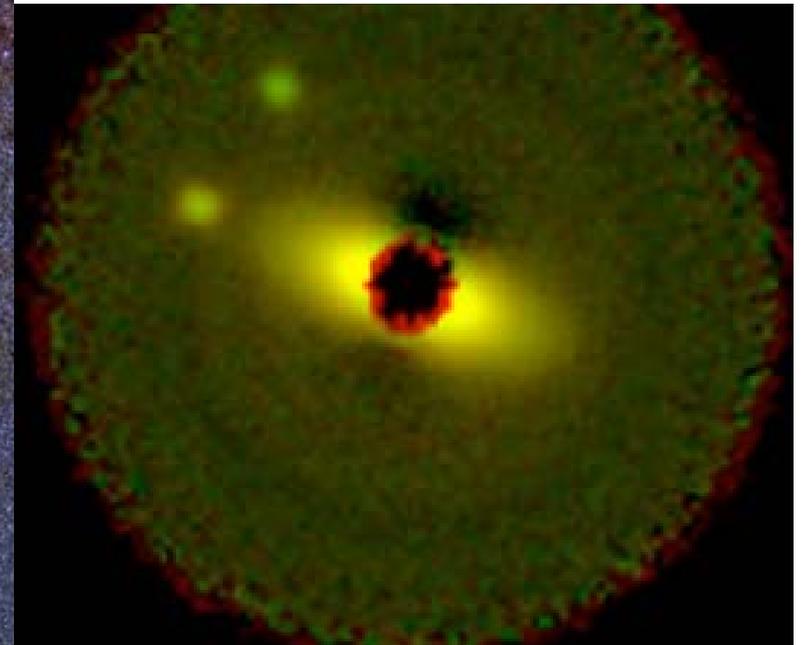
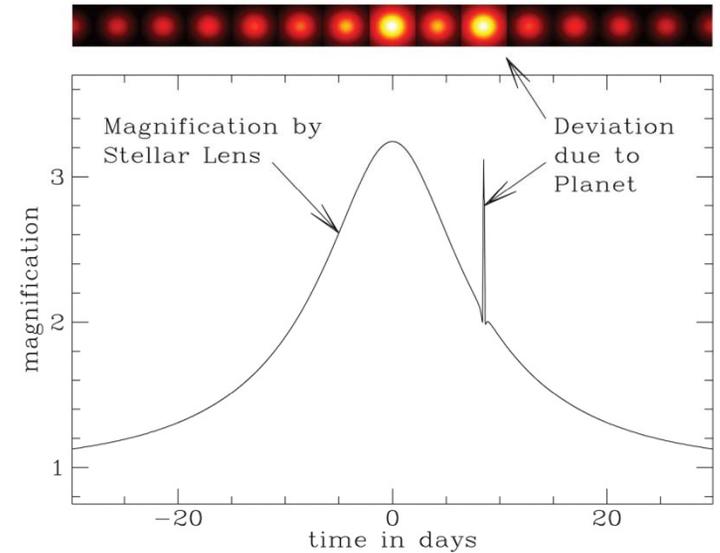
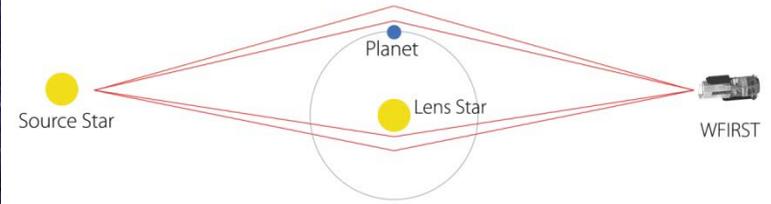


JWST (NASA/ESA/CSA) finds water on Super Earths & images young Saturns



2025-2035: Planetary System Architectures & First Nearby Earths

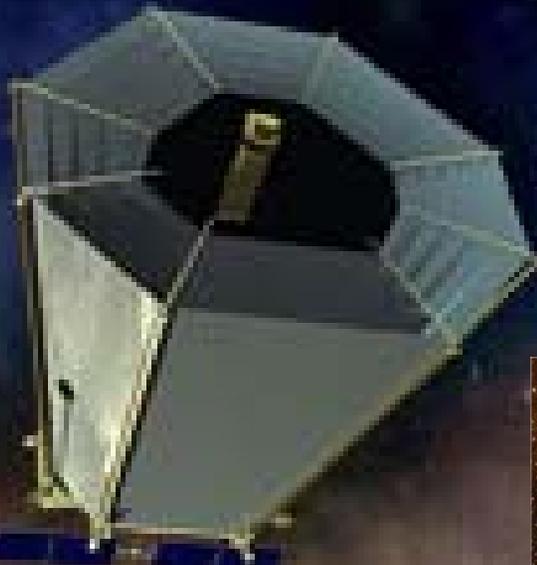
- Repurposed 2.4 m telescope (WFIRST) probes architecture beyond the “ice-line”
- ESA’s Plato finds hundreds of Earths with accurate stellar ages
- NASA’s 1.5 m coronagraphic telescope images **Earthlike planet** in HZ of α Cen B and gets spectra of dozens of gas giants
- ESA/Chinese astrometric mission finds **10 Habitable Zone Earths** orbiting 100 nearest bright stars



April 26, 2040: Life Finder Launched

Human/Robotic tended facility at L2 enables giant telescopes

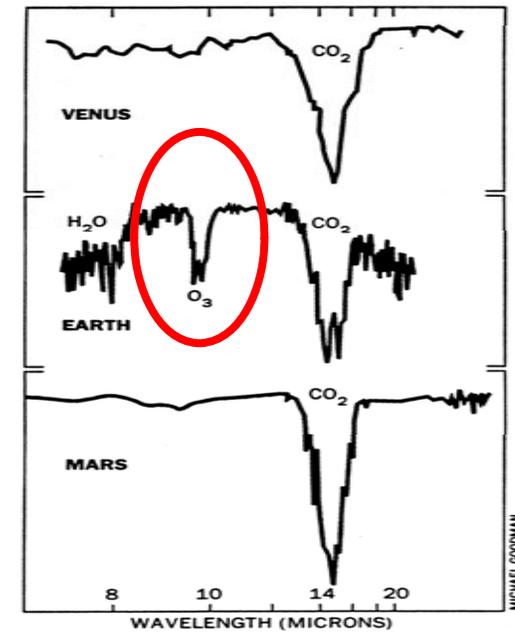
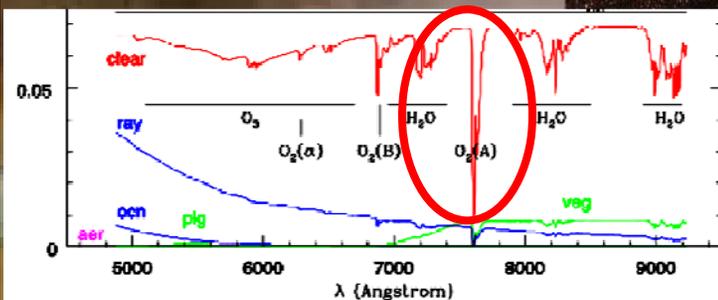
Oct 26, 2045:
3 of 10 Habitable planets
show photosynthetic life



Darwin IR Interferometer

External Occulter

Visible Coronagraph



October 26, 2062:
Complementary Searches Find Life in
Our Own and Other Planetary Systems

Mars colonists
find non-DNA
life in 2 km
deep aquifer

Jill Tarter's grand-
daughter receives first
SETI signal from a Life
Finder target star

